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Crystal et al.

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[45] Date of Patent: Mar. 28, 1995

[54] **KIT AND METHOD FOR OPENING, REFILLING AND SEALING A CARTRIDGE**

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[21] Appl. No.: **166,718**

[22] Filed: **Dec. 14, 1993**

[51] **Int. Cl.**[6] **B65B 3/00**

[52] **U.S. Cl.** **53/468;** 53/328; 53/489; 141/2; 141/18

[58] **Field of Search** 141/1, 2, 18, 21, 329, 141/370, 391, 346–349; 53/319, 328, 331.5, 359, 367, 489, 468; 347/85–87

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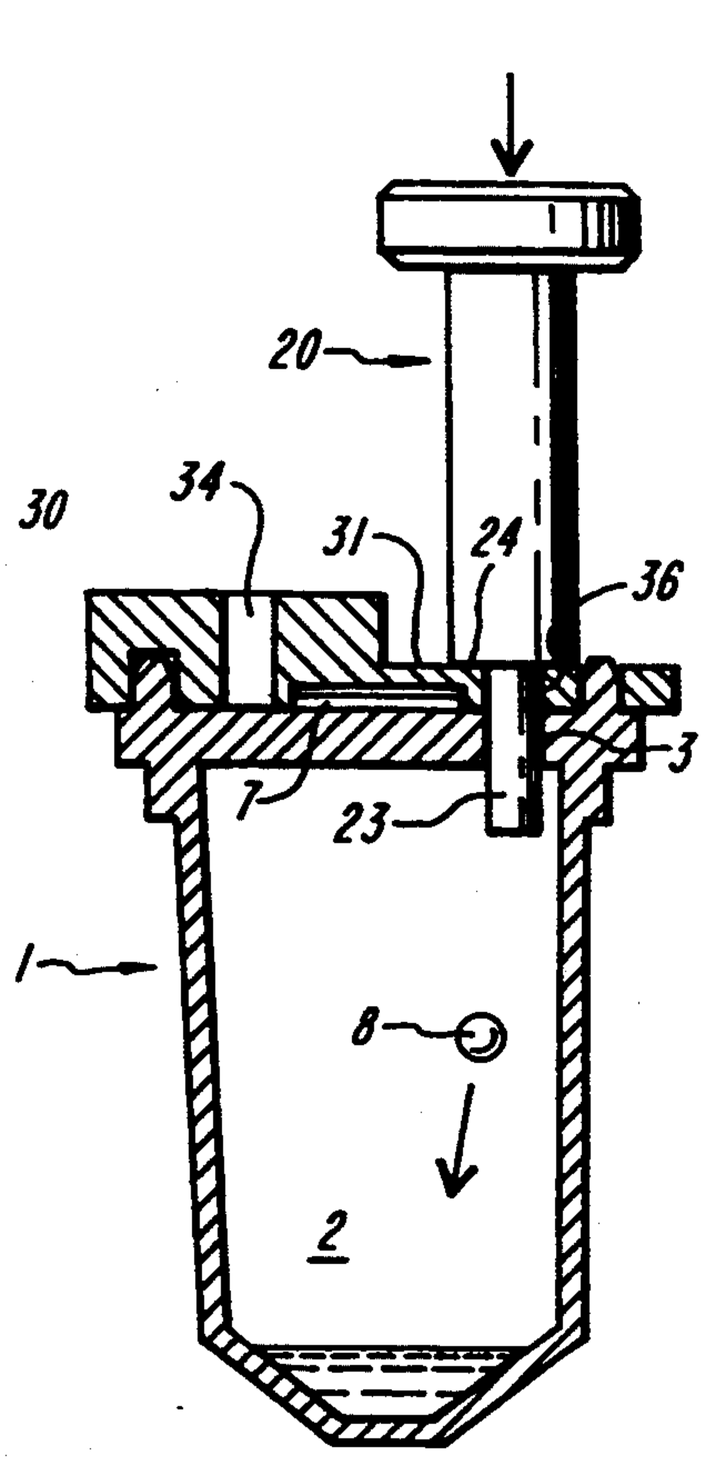
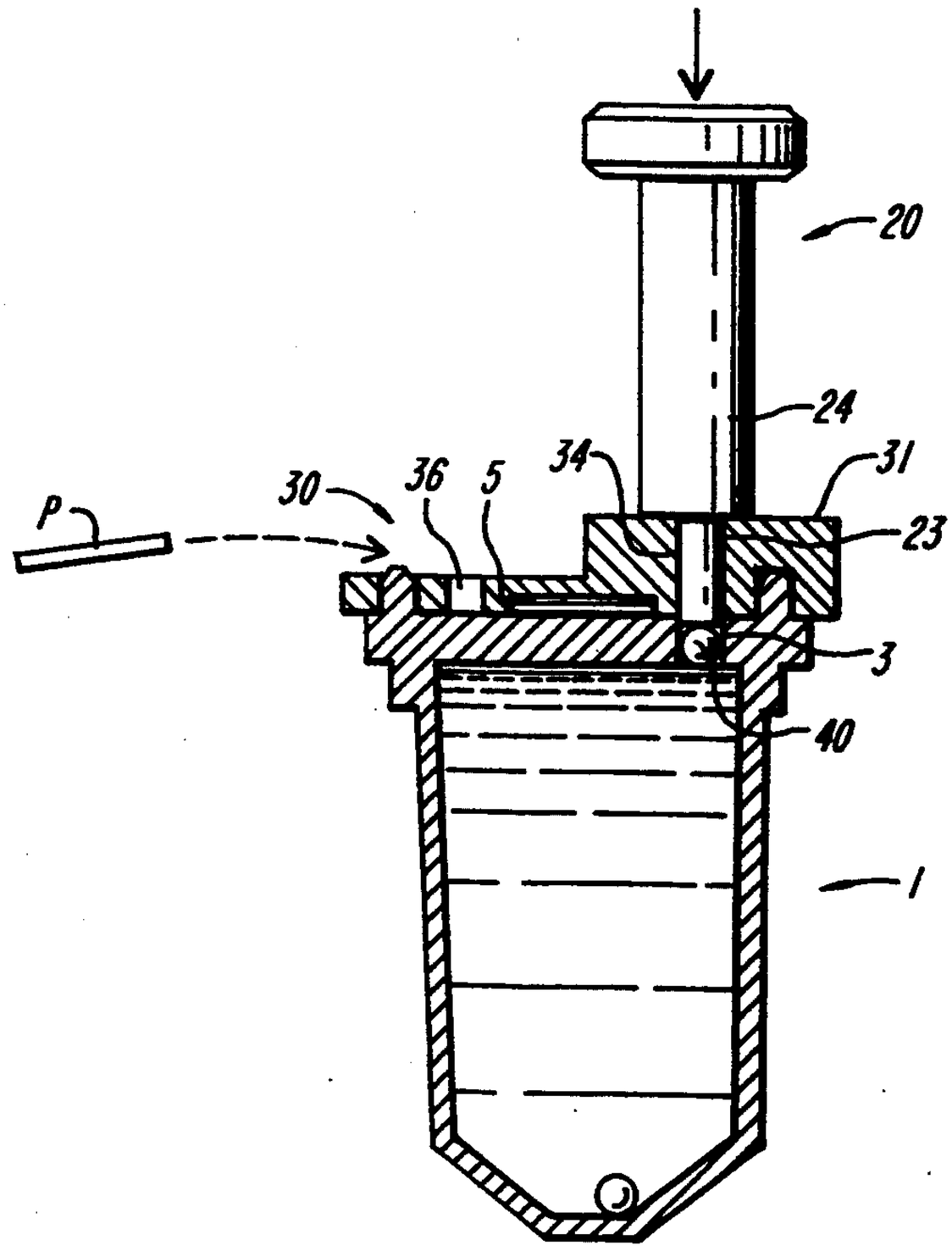
Primary Examiner—J. Casimer Jacyna
Attorney, Agent, or Firm—Lappin & Kusmer

[57] **ABSTRACT**

A kit for opening and sealing a cartridge having an interior ink reservoir coupled to an access port extending from a reference surface comprises a rigid plunger, a plate and a rigid spherical plug. The plate has one or more regions of varying thickness and a bottom surface which is complementary to the reference surface on the cartridge. The bottom surface of the plate may be matched to the reference surface of the cartridge in two distinct orientations such that a sealed access port may be opened, refilled and sealed with a rigid spherical plug by extension of the plunger through the plate in each orientation to a depth determined by the length of the plunger, the thickness of the plate in each orientation, the depth of the access port in the cartridge, and the diameter of the spherical plug.

44 Claims, 7 Drawing Sheets





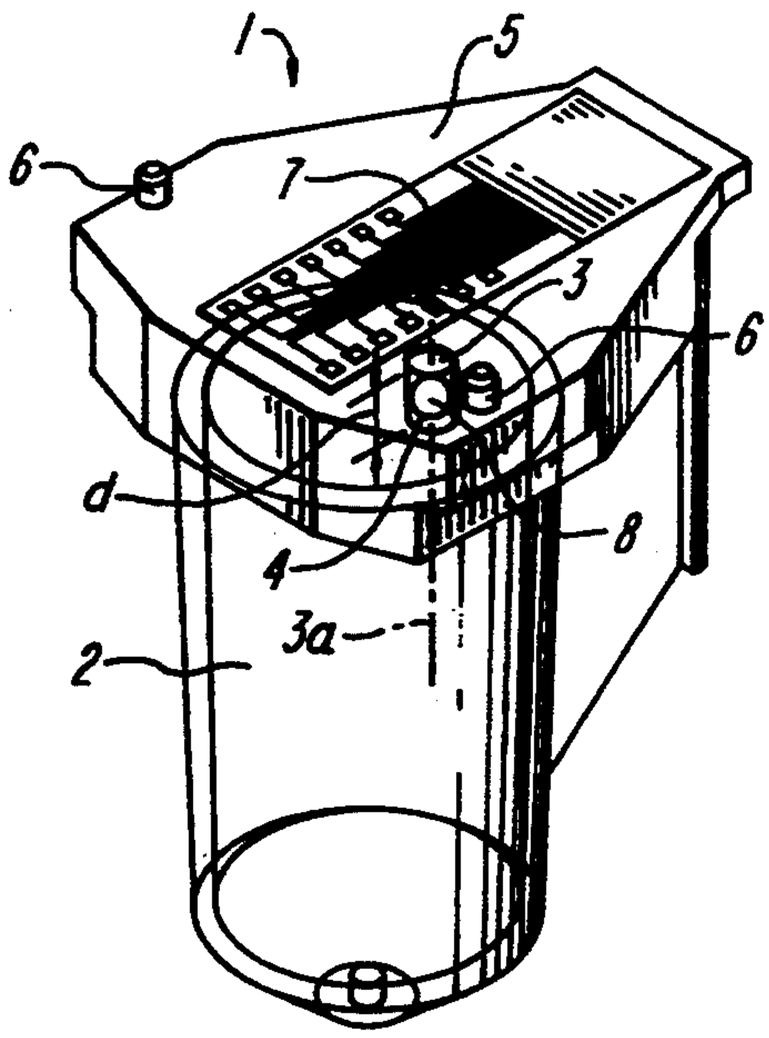


FIG. 1A
(PRIOR ART)

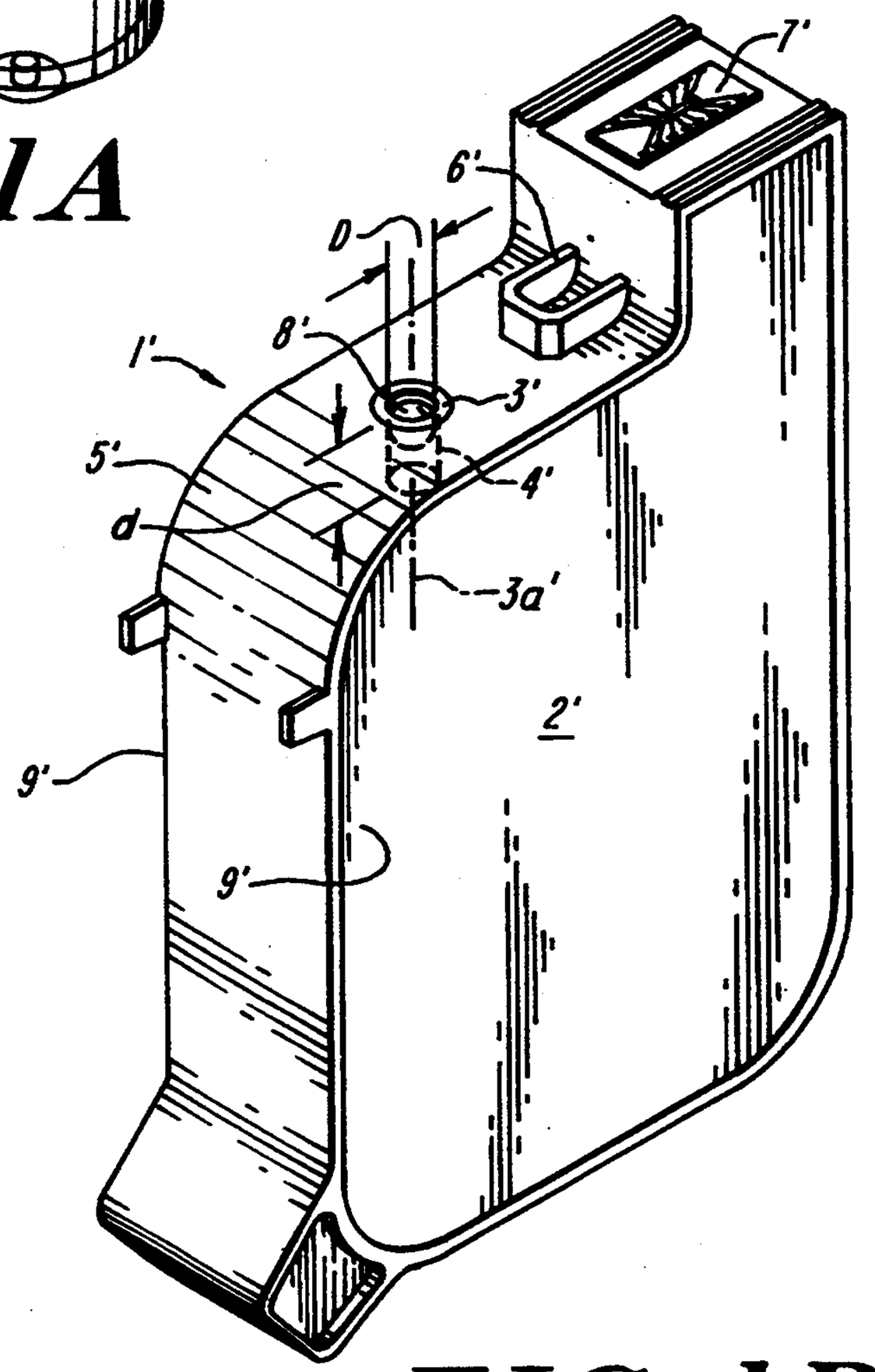


FIG. 1B
(PRIOR ART)

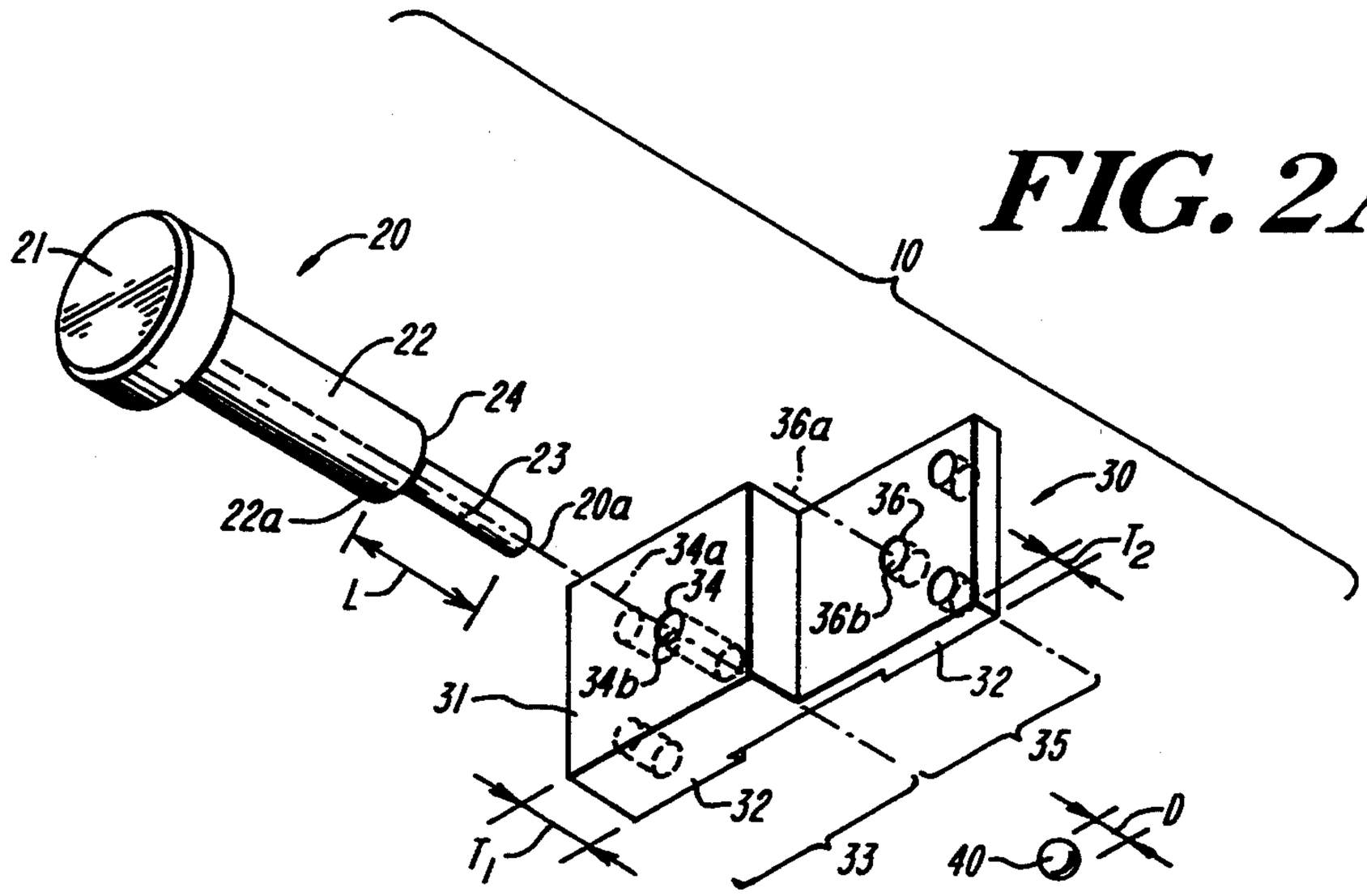


FIG. 2A

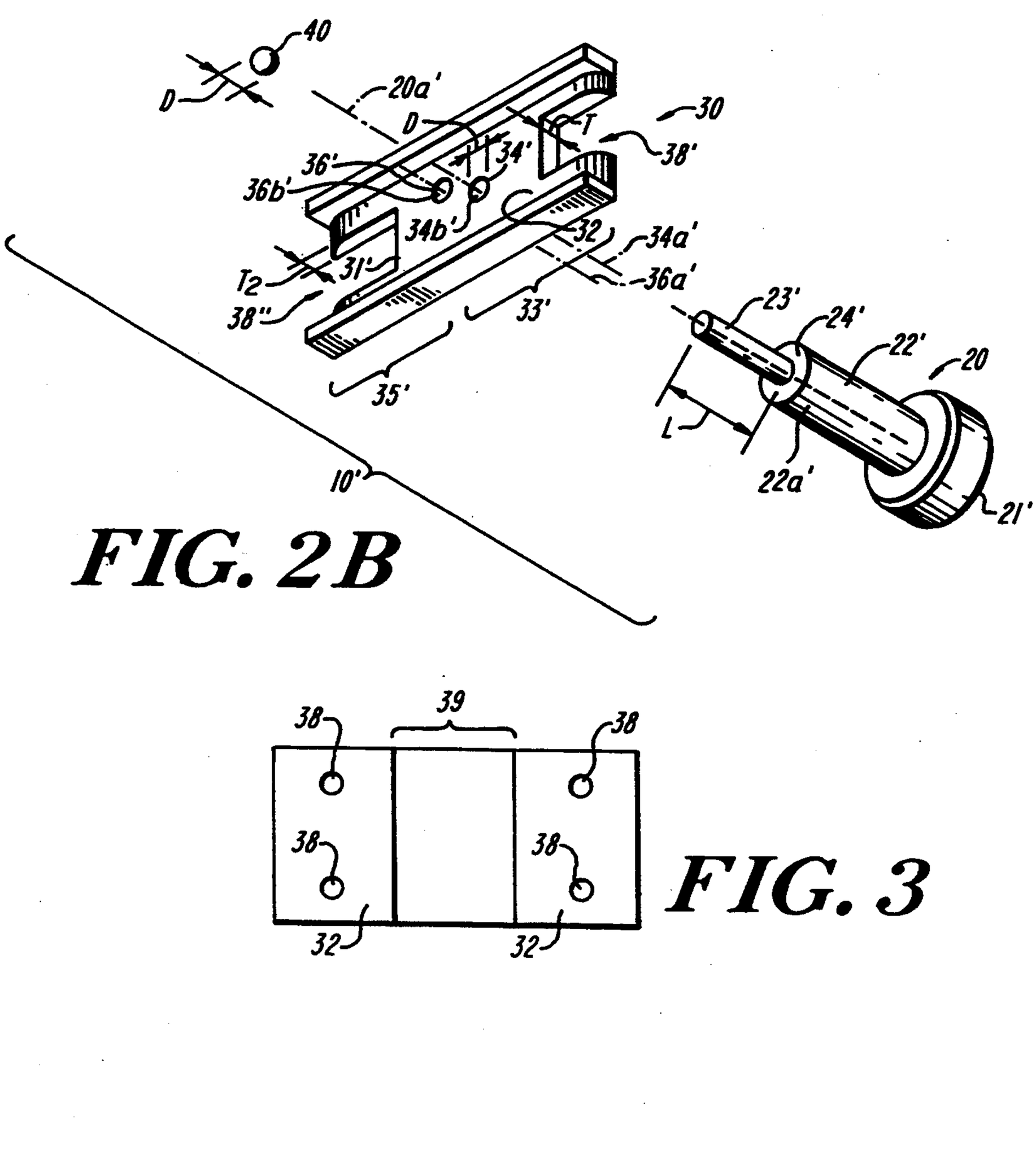


FIG. 2B

FIG. 3

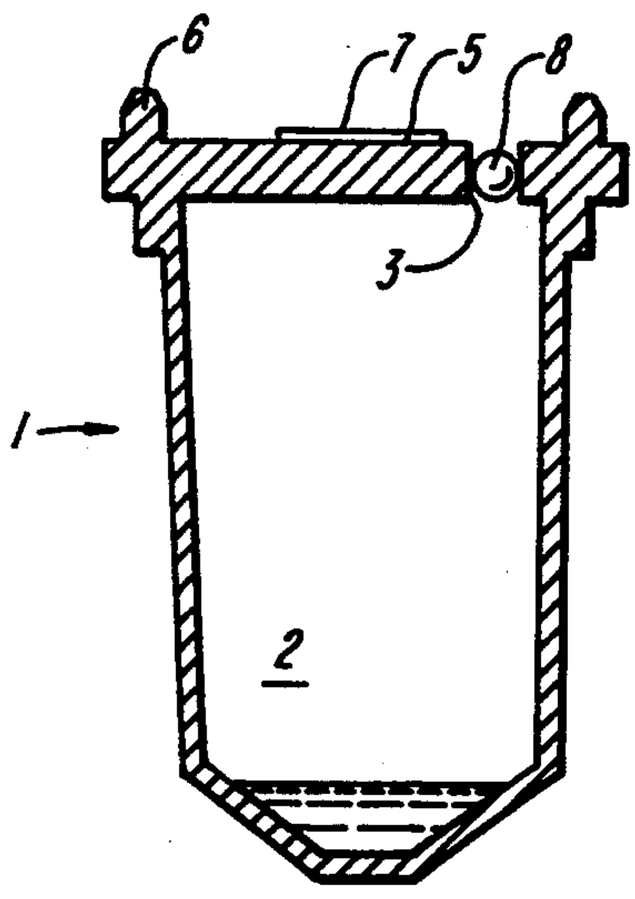


FIG. 4A

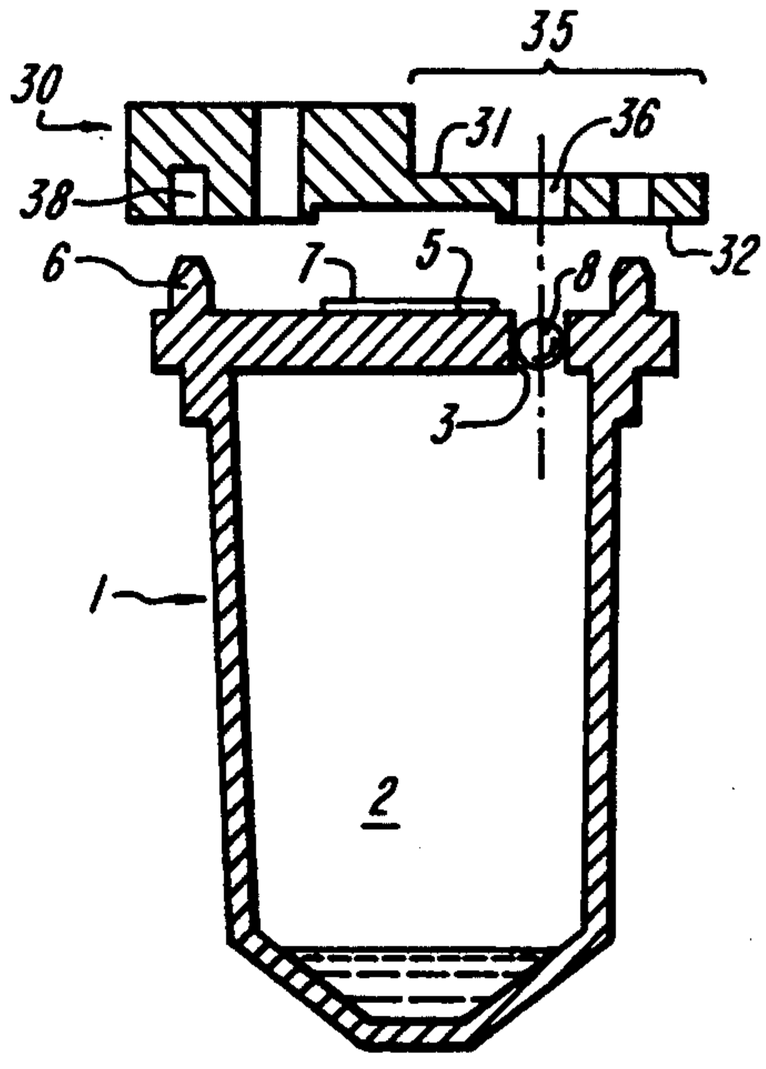


FIG. 4C

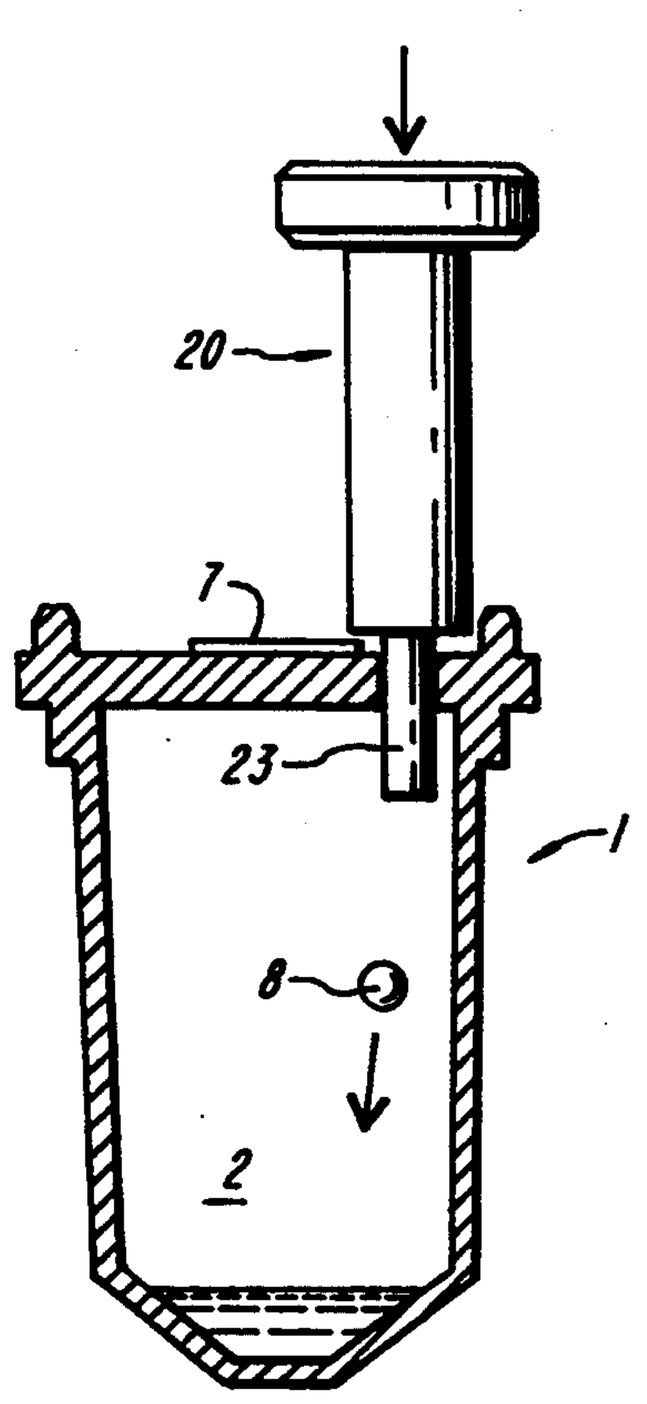


FIG. 4B

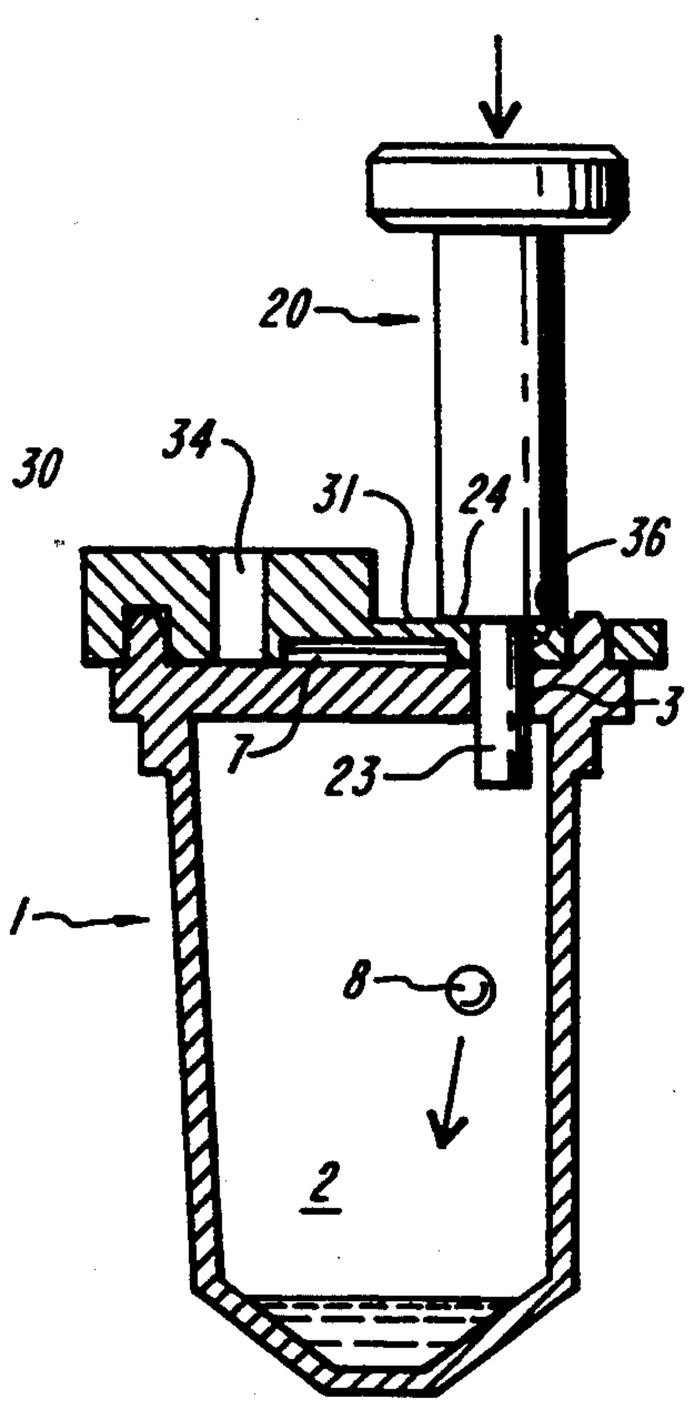


FIG. 4D

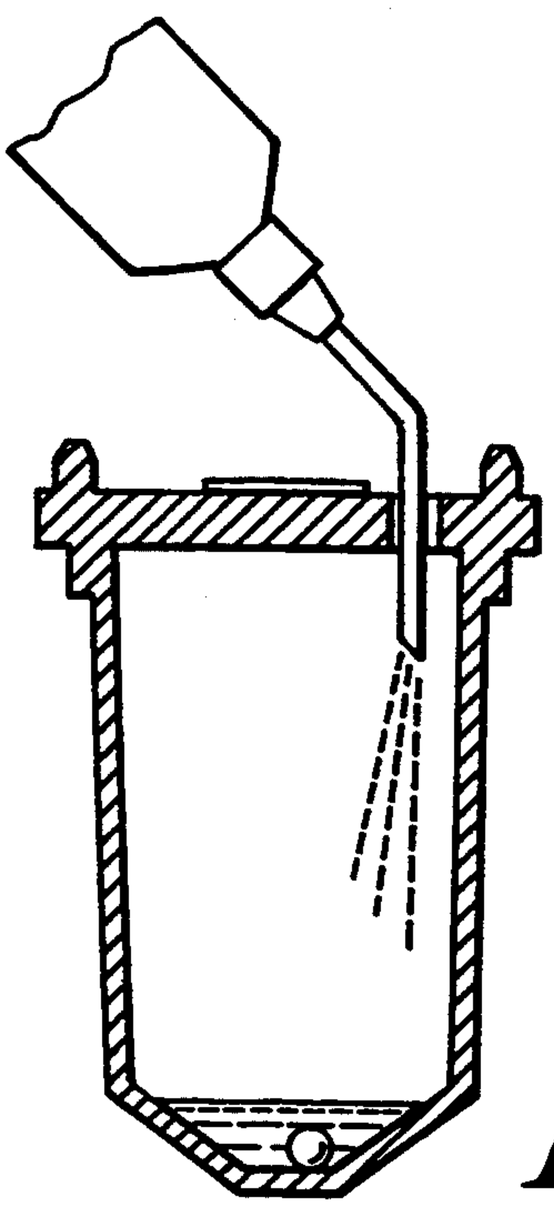


FIG. 4E

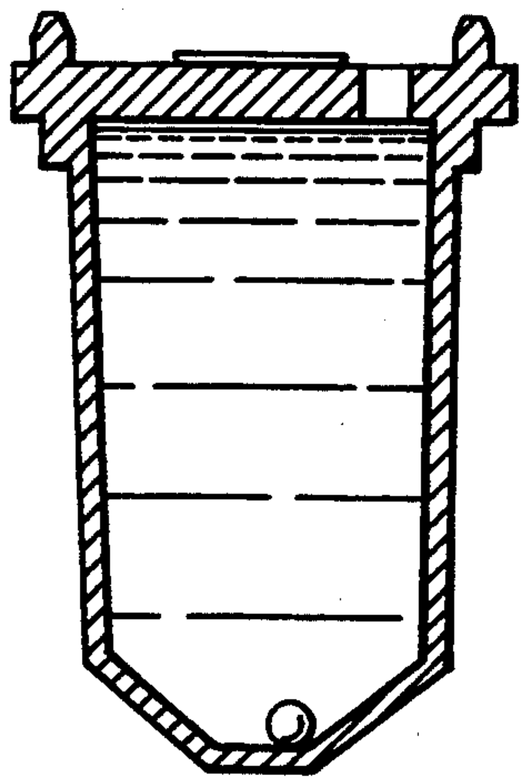


FIG. 4F

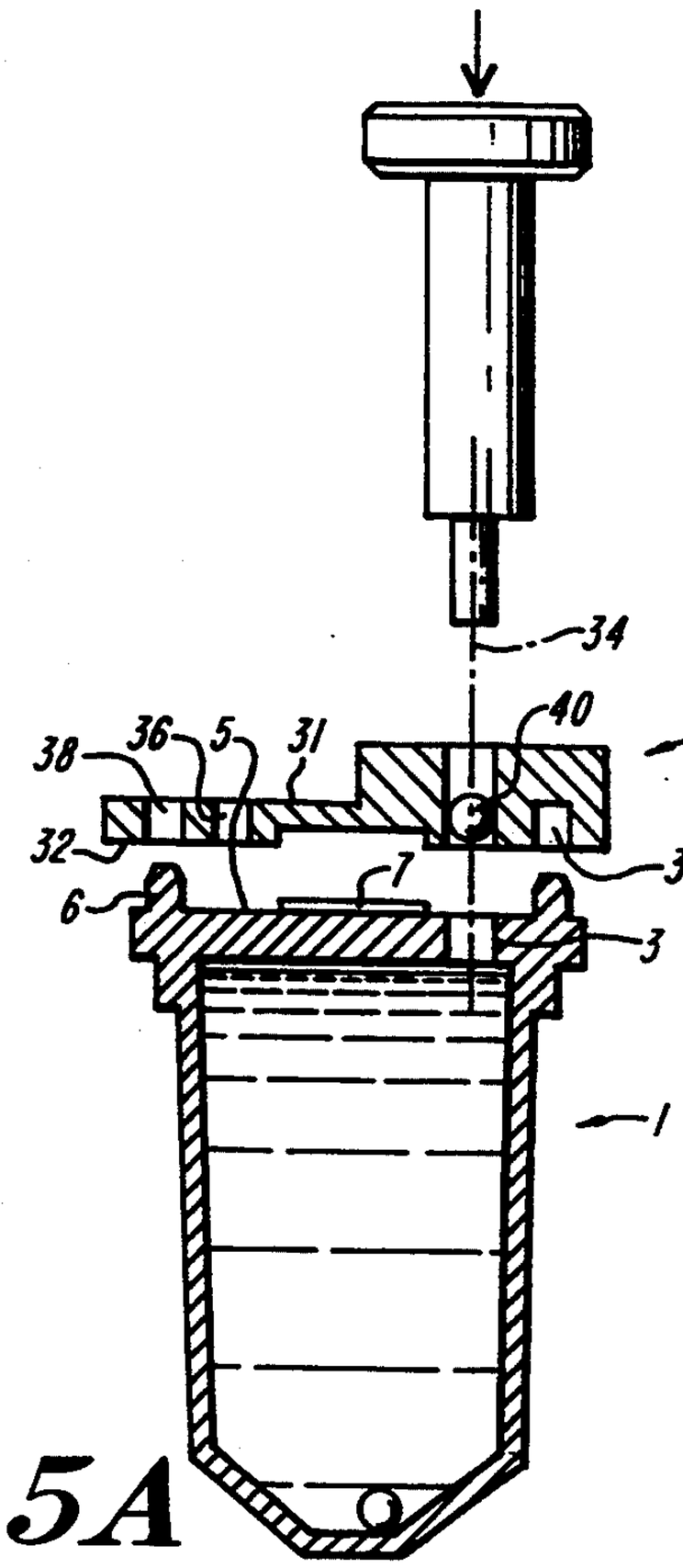


FIG.5A

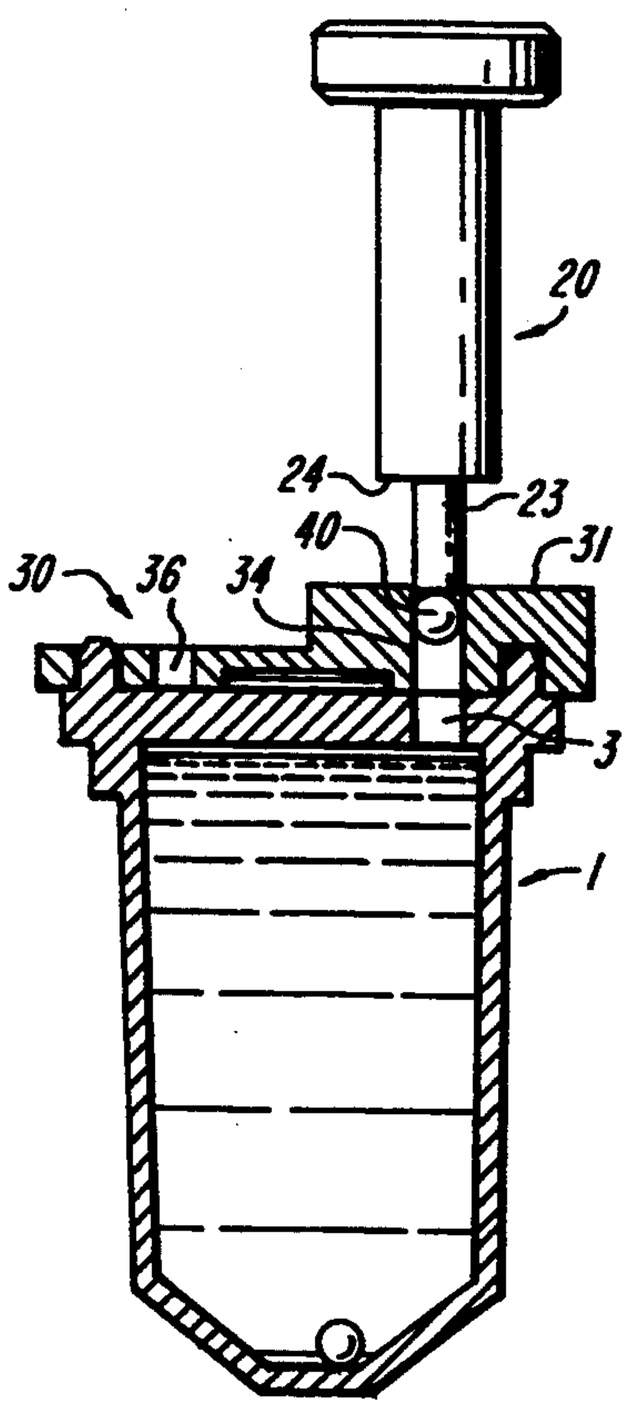


FIG.5B

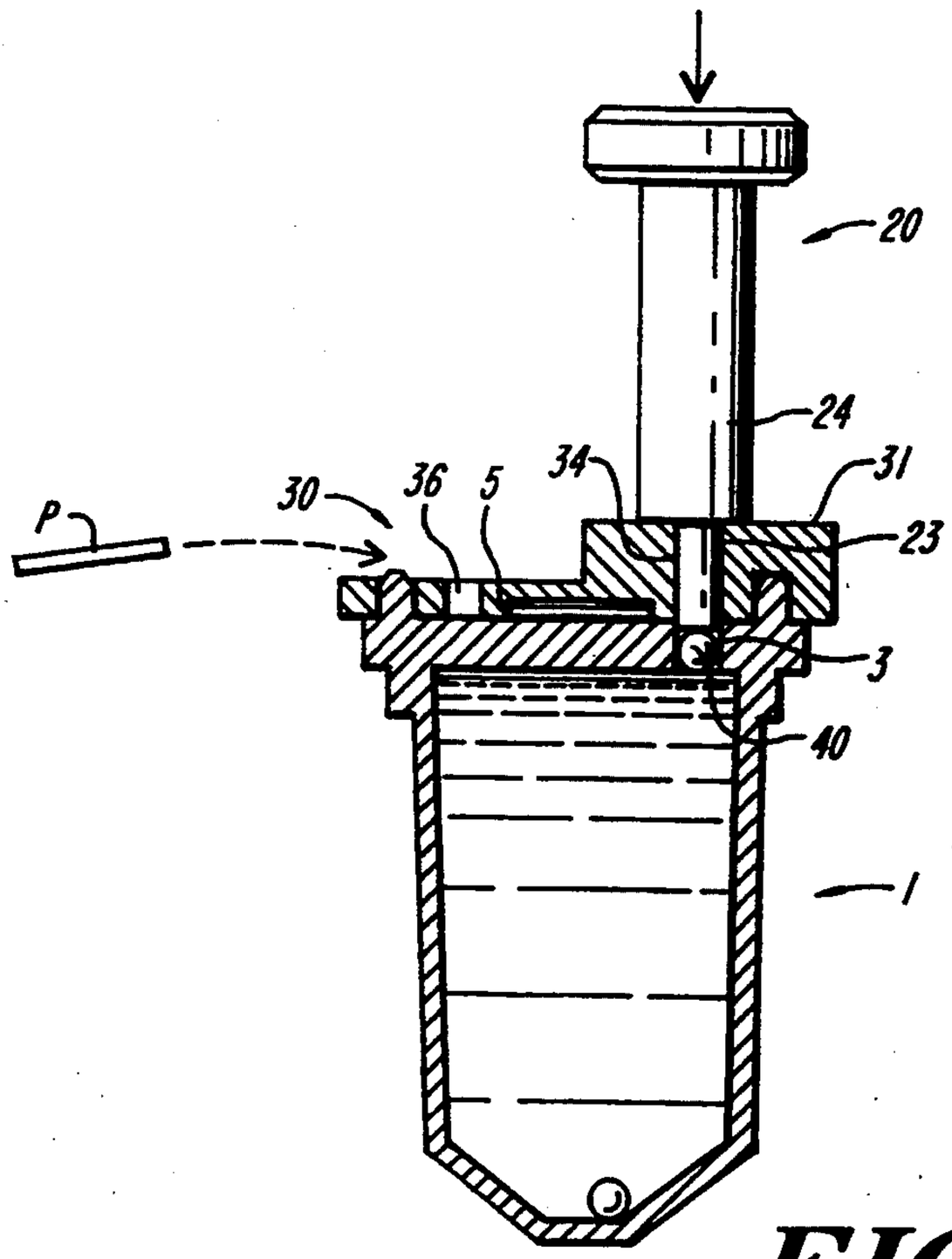


FIG. 5C

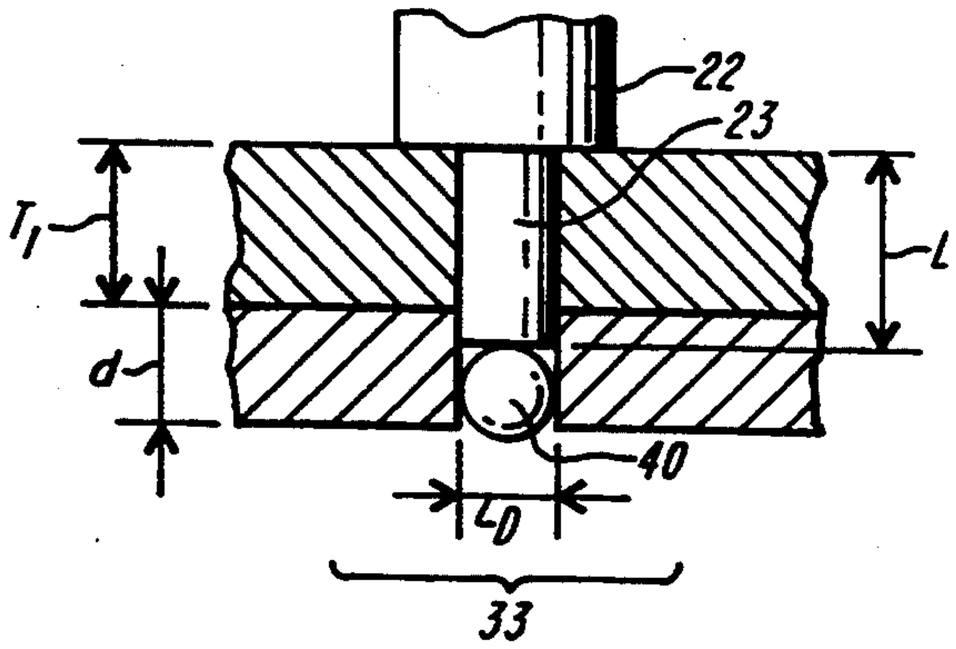


FIG. 7

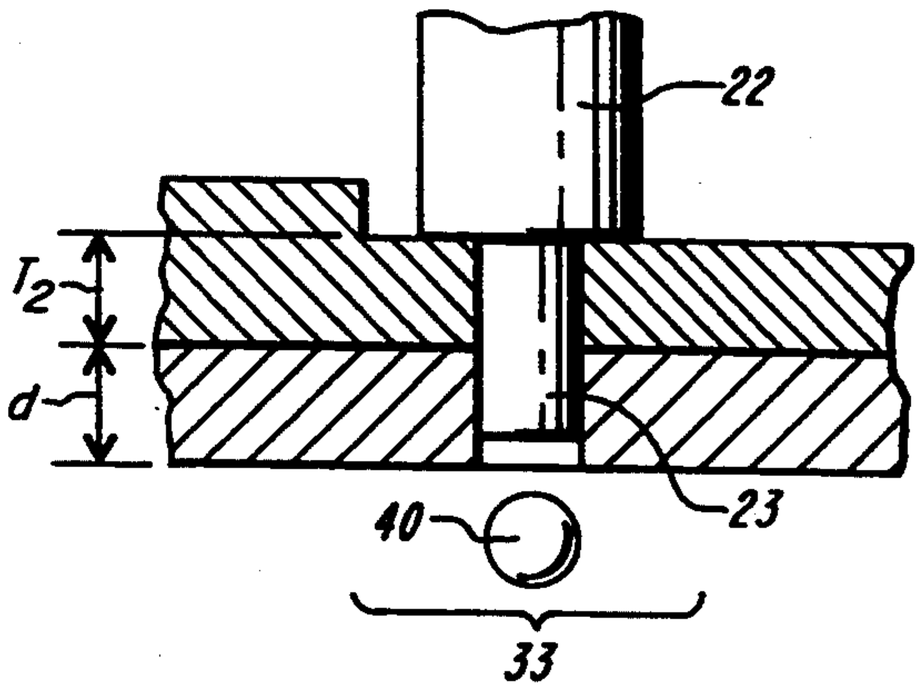


FIG. 8

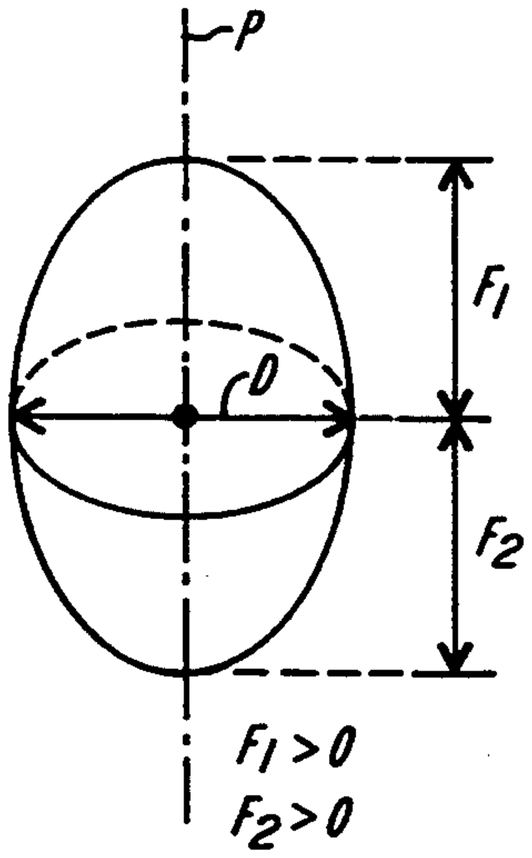


FIG. 6A

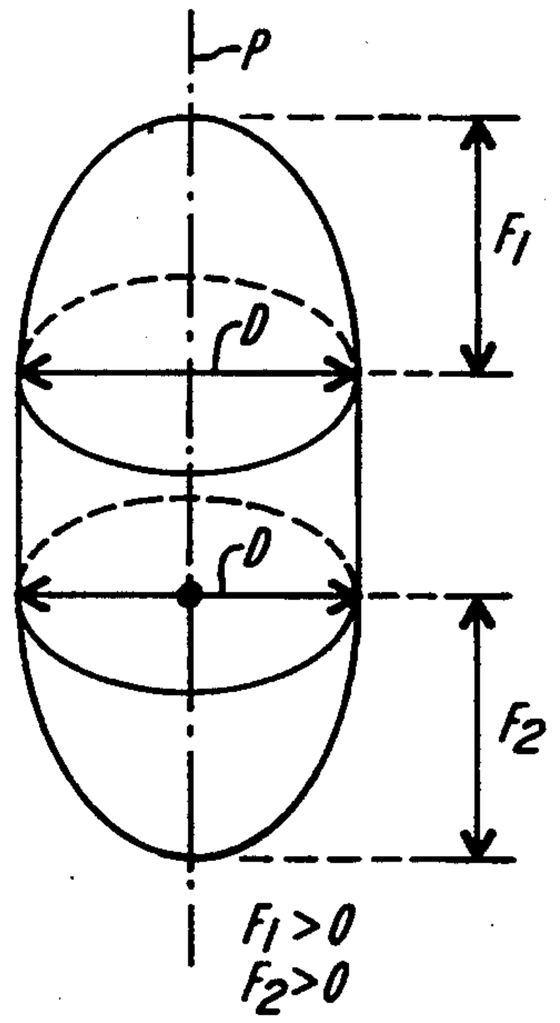


FIG. 6B

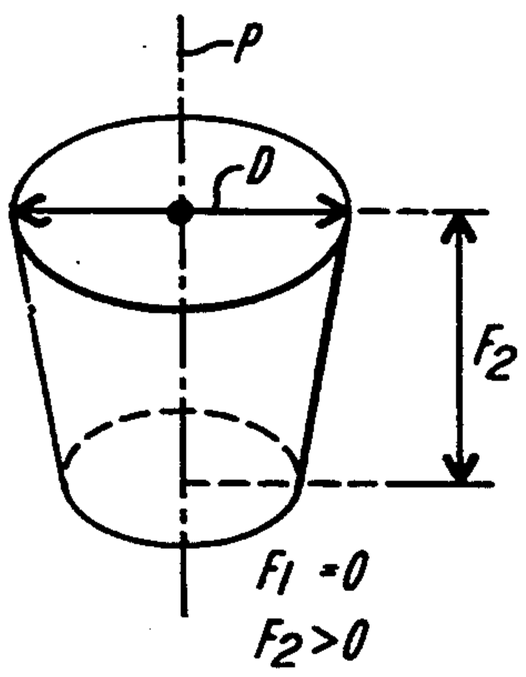


FIG. 6C

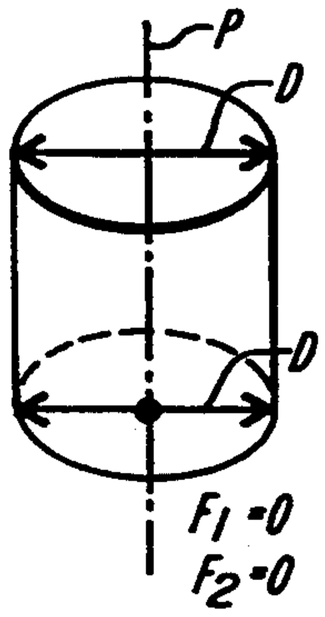


FIG. 6D

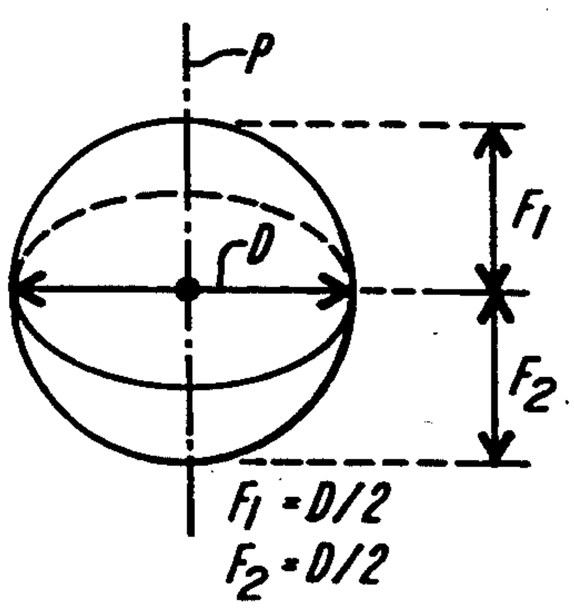


FIG. 6E

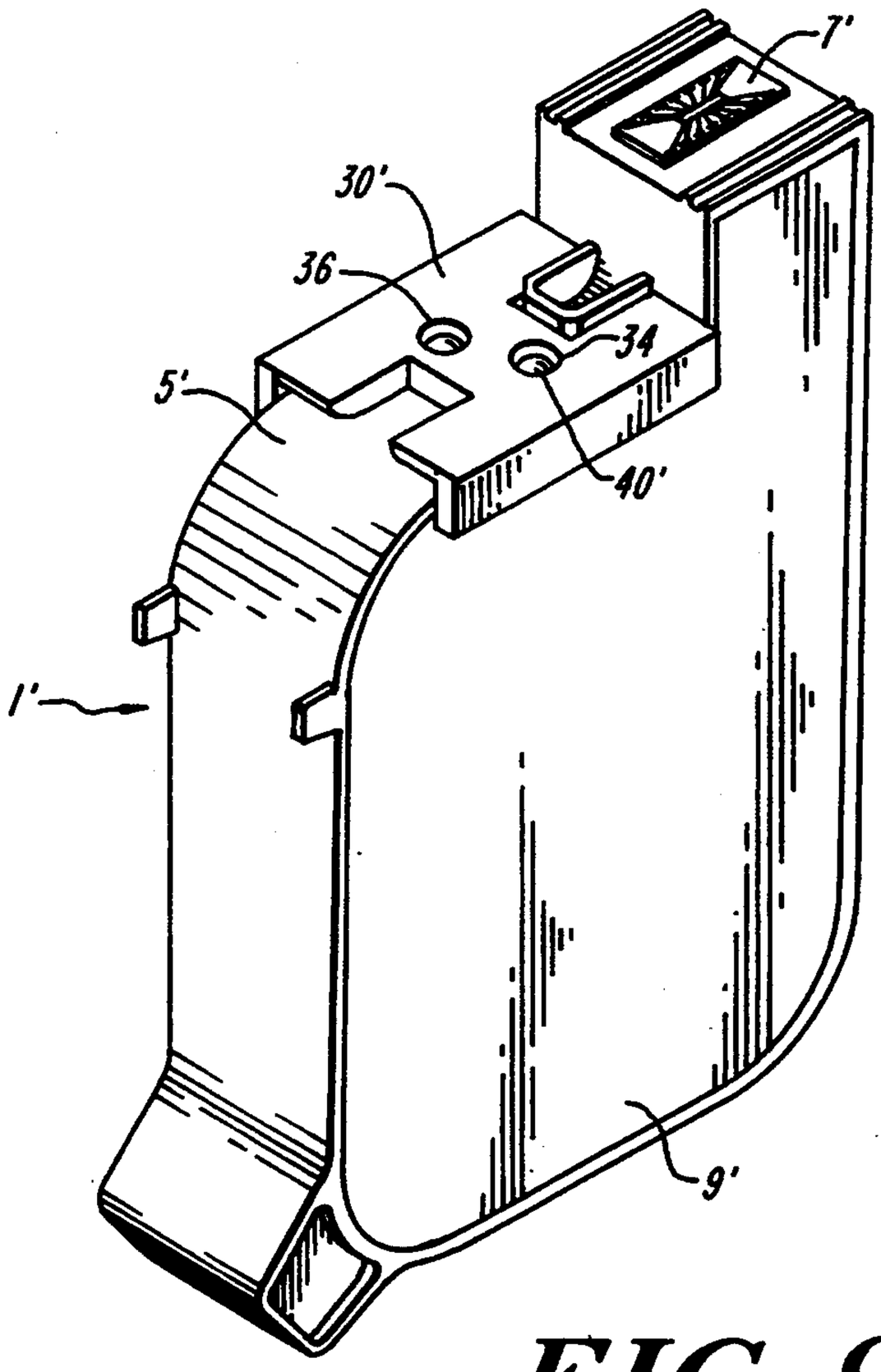
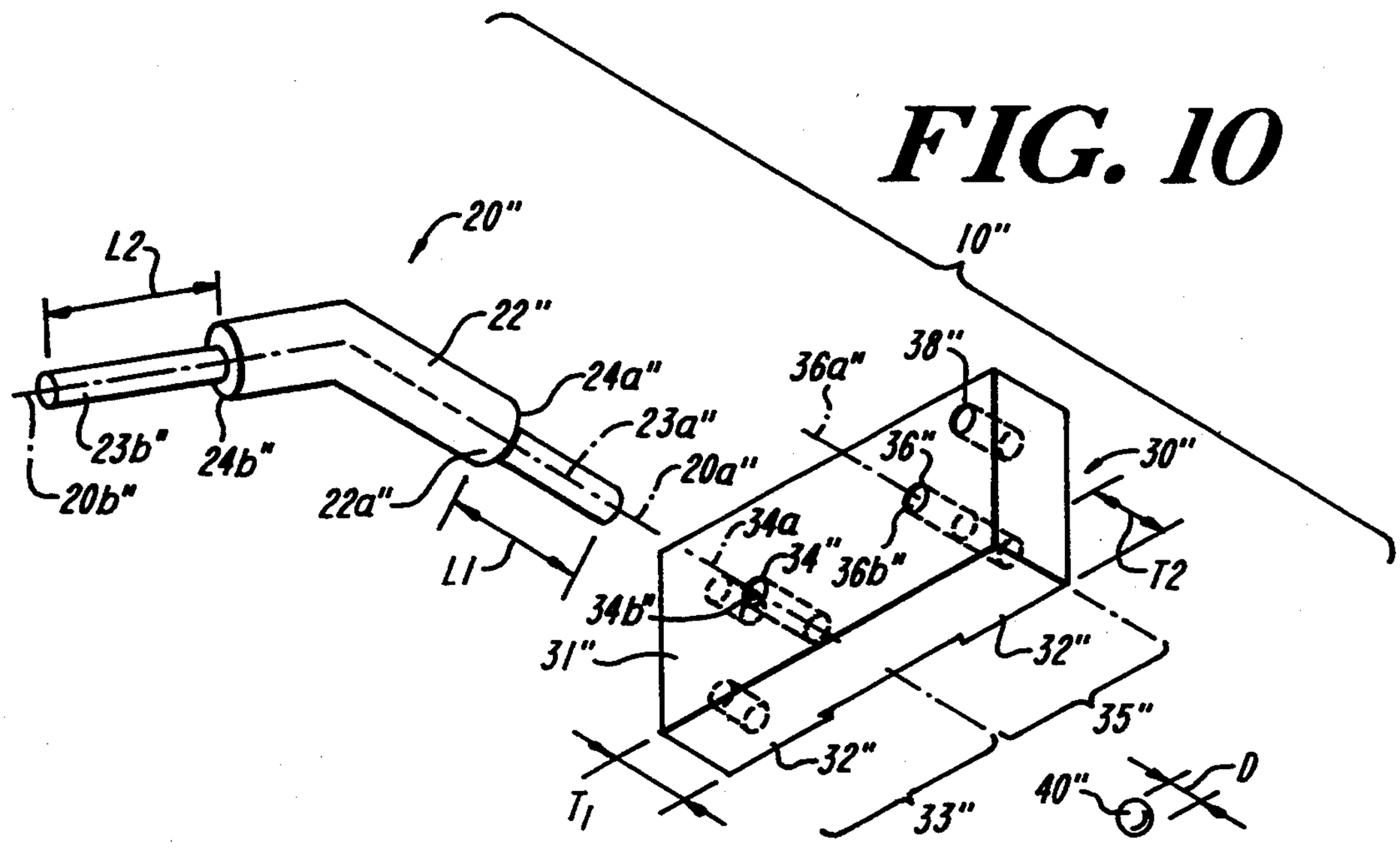

7'
30'
36
34
5'
40'
1'
9'

FIG. 9

FIG. 10


10"
20"
L2
22"
24a"
23a"
36a"
38"
36"
30"
23b"
24b"
20a"
20b"
22a"
34a
34"
36b"
T2
L1
34b"
31"
32"
35"
32"
T1
33"
40"
D

KIT AND METHOD FOR OPENING, REFILLING AND SEALING A CARTRIDGE

TECHNICAL FIELD

The invention relates generally to devices and methods for refilling cartridges of the type used in ink jet printers, and particularly to devices and methods for opening, refilling and sealing such cartridges.

BACKGROUND OF THE INVENTION

Modern ink jet printers employ a variety of ink cartridges for dispensing ink in a variety of colors. Upon depletion of the ink from a cartridge, the spent cartridges may generally be easily removed and disposed of and a new ink cartridge inserted in its place. Alternatively and more economically, the depleted ink cartridges may be removed, refilled with ink and replaced into the printer.

Various schemes have been developed to refill a depleted ink jet printer cartridge. For example, in U.S. Pat. No. 5,199,470 to Goldman, assigned to the assignee of the instant invention, a method and apparatus for refilling ink cartridges is disclosed. The apparatus comprises a kit including a device for clearing a hole in the ink cartridge to receive the new ink, and an ink injection bottle. U.S. patent application Ser. No. 086,620, filed on Jul. 1, 1993 and assigned to the assignee of the instant invention, discloses a method for refilling ink jet cartridges wherein the cartridge has an air port and an ink fill aperture and which have an expandable bladder and a bubble generator which act to equalize pressure within and without the cartridge so as to prevent leaking of ink from the cartridge. In accord with the disclosed method of the '620 application, the air port and ink fill aperture are respectively sealed and opened to receive a charge of ink therein. Once filled, the ink fill aperture of the cartridge is then sealed and the air port opened to equalize pressure within the cartridge.

Various seals are employed in ink cartridges to close the ink access ports during use and after refilling. Some cartridges utilize a rigid (e.g. metal) sphere within a compliant channel (such as the Hewlett Packard HP51640 and HP51650 cartridges), some utilize a compliant sphere within a rigid channel (such as the Hewlett Packard HP51604A and HP92261A cartridges), some utilize a compliant plug in a compliant channel (such as the Hewlett Packard HP51626A cartridge), and some utilize a rigid ball in a rigid channel with a retaining lip (such as that used with the Canon BJC600 printer). Moreover, some cartridges after a prior refilling operation utilize a (rigid or compliant) setscrew in a (compliant or rigid) channel. In all of these cases, when the ink supply is depleted from the cartridge, the plug can be removed from the channel, and the cartridge can be refilled, with the channel then being re-sealed. In the prior art it has, however, been difficult to remove the sealing element, without damaging the cartridge, and has been difficult to re-seal the cartridge, since there are no previously known kits and techniques for easily accomplishing the opening and precision re-sealing of the channel.

A disadvantage of using a cartridge having a setscrew plug is that the cartridge may not easily be reused, since the setscrew plug is difficult to remove without a specially adapted tool and is even more difficult to replace properly in the cartridge after refilling.

It is thus an object of this invention to provide a kit for opening, filling, and re-sealing a depleted cartridge employing a plug, so that the depleted cartridge could be refilled with ink and reused instead of discarded.

It is another object of the invention to provide a kit for opening and sealing a cartridge which would ensure proper placement of a seal in an ink access port of the cartridge and thus ensure against leakage of ink from the cartridge.

It is another object of the invention to provide a method for opening, refilling and resealing a cartridge upon depletion of ink therefrom, so that the cartridge may be recycled instead of discarded after a single use.

SUMMARY OF THE INVENTION

These and other objects of the invention are achieved by the present invention which, in one aspect, provides a kit for opening and sealing a cartridge having an interior ink reservoir coupled to a sealable access port in a cartridge wall. The access port has a nominally circular cross-section of diameter D and a nominally cylindrical wall which extends a distance d from an exterior reference surface of the cartridge into the interior ink reservoir along a port axis preferably perpendicular to the reference surface with a plug in the channel for sealing. The reference surface may contain one or more alignment keys. The sealing assembly of the cartridge may be of the type having a compliant plug/rigid channel, rigid plug/compliant channel, compliant plug/compliant channel, or rigid plug/rigid channel configuration. The invention may also be used without using a preformed access port; in such cases, an access port may be formed by a user drilling a hole in the reference surface, establishing an access port.

The kit comprises a plunger, a plate and a plug, typically spherical, although other shapes may be used. The plunger has a shank, the shank extending along a plunger axis to a shoulder, which has a cross-section with a maximum dimension greater than D. An elongated member extends along the plunger axis a distance **L1** from the shoulder and has a cross-section with a maximum dimension less than or equal to D. The plate has top and bottom surfaces, a thickness T_1 in a first region, and a channel extending through the first region. Preferably, that channel has a circular cross-section with diameter D at the bottom surface. The spherical plug has a circular transverse cross-section at its widest point with a diameter equal to or slightly greater than D.

Preferably, the bottom surface of the plate is complementary to the reference surface (and the alignment keys, if present) of the cartridge in a first orientation such that the channel in the first region of the plate overlies the access port in the cartridge when the bottom surface of the plate is matched with the reference surface and alignment keys of the cartridge. In other forms, the bottom surface may not be complimentary to the reference surface, but merely permit placement thereof with the respective channels aligned.

Where the plug is spherical, the length **L1** of the elongated member of the plunger exceeds the thickness of the first region T_1 minus half the diameter D of the spherical plug and is less than the sum of first thickness T_1 and the distance d along which the port extends into the cartridge, minus half the diameter D of the spherical plug. With this configuration, as described fully below, the plunger may be used to set the spherical plug in the access port following refilling of the reservoir, thereby

resealing the refilled cartridge. With other shaped plugs, the length **L1** is selected, in conjunction with **T1**, so that the same functional relationship exists.

In another form, the invention provides for a kit as described above, with the plate further including a second region having thickness T_2 which is less than T_1 and a second channel extending therethrough and having circular cross-section with diameter D. The bottom surface of the plate is complementary to the reference surface (and alignment keys of the cartridge, if present) in a second orientation such that the channel in the second region of the plate overlies the access port in the cartridge when the bottom surface of the plate is matched with the reference surface (and alignment keys) of the cartridge. The length L1 of the elongated member of the plunger is great enough so that the elongated member may be positioned to extend through the second region of the plate and into the port sufficiently far to dislodge a plug in the access port of a sealed cartridge, thereby penetrating the seal therein. In other words, the length **L1** of the elongated member of the plunger exceeds the sum of the thickness T_2 of the second region and the distance d along which the port extends into the cartridge, minus half the diameter D of the spherical plug. Again, with other shaped plugs, the length **L1** is selected, in conjunction with T_2, so that the same functional relation exists.

In still another aspect, the invention provides for a kit as described above, in which the diameter of the channels in the plate may vary throughout their respective lengths, provided the diameters have a maximum value of D at the bottom surface of the plate, thereby ensuring that a plug with a maximum diameter on the order of D may be frictionally engaged in those channels.

In still another aspect, the invention provides a method for opening, refilling and resealing a cartridge as described above. The method comprises the steps of providing a plunger and plate as described above, the plate including a plug as described above nominally inserted into the first channel. The sealed port in the cartridge is opened by inserting the elongated member of the plunger into the port to drive the plug out of the access port and into the ink reservoir. The cartridge may then be refilled through the access port with a dispensable ink. The bottom surface of the plate is then matched to the reference surface (and alignment keys of the cartridge, if any) to align the first channel of the plate with the access port in the cartridge. The cartridge is sealed by insertion of the elongated member of the plunger into the first channel of the plate from the top surface until the shoulder of the plunger shank meets the top surface, thereby pushing the plug from the channel in the plate into the access port in the cartridge. The plunger is then withdrawn from the plate and the plate removed from the cartridge.

In still another aspect, the invention provides for a method as described above, with the plate having a second region with thickness T_2 being less than thickness T_1 in the first region and where $L1 > T_2 + d - D/2$. The bottom surface of the plate is first matched to the reference surface (and alignment keys of the cartridge, if any) in the so-called second orientation to align the second channel of the plate with the sealed access port in the cartridge. The access port is opened by insertion of the elongated member of the plunger into the port through the second channel in the plate until the shoulder of the plunger shank meets the top surface of the plate so that the plug is driven out of the access port and into the ink reservoir. The plunger is then withdrawn and the plate removed from the cartridge. The cartridge is then refilled through the access port with ink. The bottom surface of the plate is then matched to the reference surfaces (and alignment keys of the cartridge, if any) in the so-called first orientation to align the first channel in the plate with the access port in the cartridge. The elongated member of the plunger is then inserted into the first channel of the plate from the top surface until the shoulder of the plunger shank meets the top surface of the plate, thereby pushing the plug from the channel in the plate into the access port in the cartridge, thereby sealing it. The plunger is then withdrawn from the plate and the plate removed from the cartridge.

These and other features of the invention will be more fully appreciated with reference to the following detailed description which is to be read in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A** and **1B** are perspective views of two prior art ink jet cartridges;

FIGS. **2A** and **2B** are perspective views of two kits according to the invention;

FIG. **3** is a bottom plan view of the bottom surface of plate **30** in kit **10**;

FIGS. **4A–4F** are a schematic representation of the sequence of steps used to open and refill a cartridge using the kit and method of the invention;

FIGS. **5A–5C** are a schematic representation of the sequence of steps used to reseal a refilled cartridge using the kit and method of the invention;

FIGS. **6A–6E** illustrate different geometry plugs that may be used with the invention.

FIGS. **7** and **8** are schematic representations of the spatial relationships between a cartridge and the kit described herein used in accordance with the kits and methods of the invention;

FIG. **9** shows a perspective view of the cartridge of FIG. **1B** with the plate of FIG. **2B** in place on the cartridge; and

FIG. **10** is a perspective view of another kit according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention provides a kit for opening, refilling and sealing a cartridge of the type used in ink jet printers, where such cartridges include an internal ink reservoir extending from a sealed ink access port in a cartridge wall. Such cartridges may be effectively recycled if they can be opened, refilled with ink, and resealed. Successful refilling and reuse of an ink jet printer cartridge will therefore depend to some extent on the design of the cartridge and the manner in which it is sealed. The kit and methods of this invention are directed to the opening and sealing of such cartridges constructed with a generally circular cross-section access port and sealed with a plug. Such cartridges may include, for example, access ports that have a smooth cylindrical wall (for seating a plug with an interference fit), or have a norminally cylindrical wall with a peripheral groove (for seating a plug), or have a nominally cylindrical wall with one or more peripheral lips (for seating a spherical plug) or have a nominally cylindrical wall with mechanical structures extending inward from the wall (for seating a plug).

Two ink jet printer cartridges particularly suited for use with the kit and methods of the invention are the Hewlett-Packard HP51604A and HP92261A cartridges used in the Hewlett Packard Thinkjet printer and the Hewlett-Packard HP51640 A, C, M, Y and HP51650A cartridges used in the Deskjet 1200C. The kit of the invention is also operative with generally similar cartridges, such as the HP51650C, M and Y cartridges used in Hewlett Packard Design Jet 650C plotters, and cartridges used in the Epson Stylus printer, the Canon BJC600 printer and similar printers. The preferrred embodiments described below illustrate the invention in conjunction with two such cartridges, but the invention may be configured with slightly different geometries to accommodate other cartridges.

FIGS. **1A** and **1B** show two prior art ink jet printer cartridges which may be opened and sealed with the kits and methods of the invention. In FIG. **1B**, elements which correspond to similar elements in FIG. **1A** are identified with identical but primed reference designations. A typical cartridge **1** has interior reservoir **2** for containing ink or other dispensable liquid. The interior reservoir **2** is coupled to sealable port **3**. The port **3** has a circular cross-section with diameter D and a relatively rigid cylindrical wall **4** extending a distance d into the cartridge along port axis **3***a* and perpendicular to reference surface **5** and one or more alignment keys **6** on the reference surface **5** of the cartridge. The interior surface of the compliant cylindrical wall **4** of the port **3** may be smooth, or it may be textured with, for example, a helical thread pattern. The reference surface **5** of the cartridge **1** is generally notched or otherwise mechanically keyed in order to facilitate placement and proper alignment of the cartridge **1** in a conventional ink jet printer. Various alignment key configurations include pins, projections, notches, keyways and channels. The reference surface **5** may additionally include electrodes **7** which selectively control the release of ink through apertures in the print head. The port **3** is sealed with plug **8**. The plug **8** lodges securely in the port **3** and may be a rigid object of any shape, including a sphere, cylinder, conic frustum, or ellipsoid, for example, constructed of a relatively compliant material, which has a diameter slightly greater than D at its widest point. In other forms, cartridges may have channel/plug assemblies with compliant/rigid, compliant/compliant, or rigid/rigid characteristics. The cartridge **1'** shown in FIG. **1B** is generally similar to that of FIG. **1A** and has interior reservoir **2'** defined by reference surface **5'** and compliant sidewalls **9'**. In the illustrated example, the cartridge **1'** includes a relatively compliant cylindrical wall **4'** and a relatively rigid plug **8'**.

FIGS. **2A** and **2B** show kits **10** and **10'** according to the invention. The kit **10** of FIG. **2A** is suitable for use with the cartridge of FIG. **1A**. FIG. **2B** shows a similar kit **10'** for use with the cartridge of FIG. **1B**, and is particularly adapted for use in re-filling two of such cartridges. In alternative forms, the plate of FIG. **2B** may be configured to fill in N (where $N>2$) cartridges; for example, two plates may be arranged at right angles and effectively superimposed to provide a four pointed "star" structure for filling four cartridges. In FIG. **2B**, elements which correspond to similar elements in FIG. **2A** are identified with identical but primed reference designations.

The kit **10** comprises a plunger **20**, a plate **30** and a spherical plug **40**. The plunger **20** is preferably made of any relatively rigid material and includes a head **21** at one end of the plunger and a shank **22** extending along a plunger axis **20***a* from the head **21**. The head **21** is of a size and shape to be conveniently grasped by the user. The shank **22** has a cross-section of any shape where, at the distal end **22***a*, the largest cross-sectional dimension of the shank **22** is greater than D, the diameter of the port **3** in the cartridge **1**. An elongated member **23** extends longitudinally from the shank **22** along plunger axis **20***a*. Elongated member **23** has a circular cross-section with a diameter having a maximum dimension less than or equal to D transverse to plunger axis **20***a*. The elongated member **23** extends a distance **L1** from the shank **22**, which forms a shoulder **24** with elongated member **23** at its point of origin from the shank **22**. This plunger design permits extension of the elongated member **23** through a port or ports having a diameter D or greater to a maximum depth **L1**.

The plate **30** includes top surface **31** and bottom surface **32** and has thickness T_1 in a first region **33**. A first channel **34** extends through the first region **33** of the plate **30** between the top and bottom surfaces **31** and **32**, respectively, along a first channel axis **34***a* perpendicular to the principal plane of the plate **30**. The first channel **34** has a circular cross-section and is adapted to hold a plug therein in a friction fit. The channel **34** has a diameter equal to or greater than D at the bottom surface **32** of the plate **30**. The channel diameter may be constant between the top and bottom surfaces of the plate **30**, or it may vary from the bottom surface **32** to a lesser diameter value away from the bottom surface **32**. The first channel **34** is defined by a generally cylindrical wall **34***b* which may have a smooth or textured surface. In the illustrated embodiment, the wall **34***b* is relatively compliant, although in other embodiments (such as ones for use with cartridges having rigid ink access channels and compliant plugs), the wall **34***b* may be relatively rigid.

The bottom surface **32** of the plate is complementary to the reference surface **5** (and also to alignment keys **6**) of the cartridge **1**; that is, the bottom surface of the plate is preferably constructed to match, or mate with, the reference surface (and alignment keys on the reference surface) of the cartridge. The term "match" or "matching", as used herein, refers to the temporary placement of surfaces adjacent to one another such that the features of the respective surfaces fit together as if they formed a matched pair. More particularly, the bottom surface of the plate is constructed to match the reference surface and alignment keys on the reference surface of the cartridge in a first orientation which matches the first channel in the plate to the access port in the cartridge. In some embodiments, a non-matching surface can be used as long as that surface permits placement of the plate **30** against the reference surface **5** with the respective channels **4** and **34** adjacent and aligned.

The first orientation is illustrated in FIGS. **5A–5C**. When the bottom surface **32** of the plate **30** is matched to the reference surface **5** and alignment keys **6** of the cartridge **1** in the first orientation, the first channel axis **34***a* and the port axis **3***a* are collinear. In the illustrated embodiment, the plate **30** may be constructed of any material which is relatively compliant in comparison to the material used for the spherical plug.

In the illustrated embodiment, the spherical plug **40** included in the kit **10** is constructed of any material which is relatively rigid in comparison with the material from which the cylindrical wall **4** of the port **3** in the cartridge **1** and the cylindrical walls **34***b* of the channels

34 in the plate 30 are constructed. As noted above, in other embodiments the relative rigidity and compliance characteristics may differ. The spherical plug 40 has circular cross-section at its widest point, with a diameter slightly greater than D at its widest point. When the spherical plug is nominally positioned inside a channel in the plate 30 it remains there in a friction, or interference, fit between the plug 40 and the relatively compliant channel walls 34. However, it is not permanently lodged within the channel; it can be dislodged upon the application of nominal force to it, such as by the plunger 20. While the invention is principally described herein with a spherical plug, having a diameter D, it will be understood that other shaped plugs may be used. In the latter form, references to the diameter D of the circular cross-section remain the same for the spherical form; however, where the plug is eccentric with respect to the circular cross-section, the dimension of the eccentricity in the direction perpendicular to the widest point circular cross-section corresponds, to the diameter D in the spherical case, and the relationships defining L1 will be understood to refer to the portion of that dimension of the plug (F) as measured from the widest point cross-section toward the so-called top surface of the plate, with the plug in place in the plate.

A number of such plugs are illustrated in FIGS. 6A–6E, each plug extending along a plug axis P and having a circular cross-section transverse to axis P with a maximum diameter D at a point between a first end and a second end. FIG. 6A shows an ellipsoid plug; FIG. 6B shows an extended (with a central cylindrical section) ellipsoid plug; FIG. 6C shows a conic frustum plug; FIG. 6D shows a cylindrical plug; and for comparison, FIG. 6E shows a spherical plug. In all of those configurations, the distance F is defined from the one end to the closest circular crosssection with diameter D. In FIGS. 6A and 6B the distance F is greater than zero from either end of the plug; in FIG. 6C, the distance F is zero from the top (as shown) end and is greater than zero from the bottom (as shown) end; in FIG. 6D, the distance F is equal to zero from both the top and bottom ends; and in FIG. 6E, the distance F equals D/2 from each of the top and bottom ends. For these various plugs, the following relationships are contemplated by the invention: $T_1$31 $F<L1<T_1+d-F$ and $L1>T_2+d-F$. The examples below are for the illustrated spherical plug where $F=D/2$.

As FIG. 7 illustrates for the spherical plug example, the length L1 of the elongated member of the plunger is greater than the thickness T_1 of the first region of the plate minus half the diameter D of the spherical plug, yet less than the sum of thickness T_1 and distance d by which the access port extends into the cartridge, minus half the diameter D of the spherical plug. With this relationship between the length of the elongated member of the plunger, the plate thickness in the first region and the diameter of the spherical plug ensures that when the plate is positioned onto the cartridge in the first orientation, as shown in FIG. 7, the elongated member of the plunger extends through the first channel in the plate only far enough into the access port in the cartridge to position a spherical plug in the access port, thereby sealing it. The shoulder of the plunger will not permit the elongated member to extend far enough into the access port to push the spherical plug beyond the distance d by which the access port extends into the cartridge.

While not necessary for the invention, the plate 30 of FIG. 2A further includes a second region 35 having thickness T_2, where T_2 is less than T_1, as shown in FIG. 2A. A second channel 36 extends through the second region of the plate between the top and bottom surfaces along a second channel axis 36*a* perpendicular to the principal plane of the plate. The second channel 36 also has a circular cross-section having diameter greater than or equal to D at the bottom surface 32 of the plate 30. The second channel diameter may also be constant between the top and bottom surfaces of the plate, or it may vary from diameter D at the bottom surface 32 to a lesser diameter value away from the bottom surface. The second channel 36 is also defined by a generally cylindrical wall 36*b* which may have a smooth or textured surface. The second channel 36 has the same compliancy characteristics as channel 34.

The bottom surface 32 of the plate 30 is shown in plan view in FIG. 3. That bottom surface 32 preferably includes alignment keys 38 (a plurality of holes extending partially or fully therethrough) adapted for complementary engagement with alignment keys 6 of the cartridge 1. A depressed region 39 extends into the bottom surface 32 to provide clearance for the electrode assembly 7 on the cartridge 1. The bottom surface 32 is preferably constructed to match the reference surface 5 and alignment keys 6 on the reference surface 5 of the cartridge 1 in a second orientation (for example, a 180° offset from the first orientation; compare FIGS. 4C and 5A) which matches the second channel 36 in the plate 30 to the access port 4 in the cartridge 1. This second orientation is illustrated in FIG. 8. When the bottom surface 32 of the plate 30 is matched to the reference surface 5 and alignment keys 6 of the cartridge 1 in the second orientation, the second channel axis 36*a* and the port axis 3*a* are collinear. Again, other configurations may be used as long as the plate 30 may be positioned with channel adjacent to and aligned with the access channel 4 of a cartridge.

The length L1 of the elongated member 23 of the plunger 20 is greater than the sum of the thickness T_2 of the second region of the plate and the distance d by which the access port extends into the cartridge, minus half the diameter D of the spherical plug. With this relationship between the length of the elongated member of the plunger, the plate thickness in the second region and the diameter of the spherical plug ensures that when the plate is positioned onto the cartridge in the second orientation, the elongated member of the plunger extends through the second channel in the plate sufficiently far into the access port in the cartridge to dislodge a sealing plug therein, as shown in FIG. 8.

As an alternative embodiment, the plate 30′ is shown in FIG. 2B, viewed from its bottom surface 32′. This alternative embodiment, adapted for use with the cartridge of FIG. 1B, includes a second region 33′ having thickness T_1 and a mechanical alignment key 38′ adapted to interfit with alignment key 6′ of cartridge 1′. A first channel 34′ extends through the first region 33′ of the plate 30′ between the top surface 31′ and bottom surface 32′ along a second channel axis 34*a*′ perpendicular to the principal plane of the plate 30′. The first channel 34′ also has a circular cross-section having diameter D at the bottom surface 32′ of the plate 30′. The diameter of the first channel 34′ may also be constant between the top and bottom surfaces 31′ and 32′, respectively, of the plate 30′, or it may vary from diameter D at the bottom surface 32′ to a lesser diameter value away from

the bottom surface of the plate. The first channel **34′** is also defined by a compliant, generally cylindrical wall **34***b′* which may have a smooth or textured surface. The bottom surface **32′** of plate **30′** is contoured to be complementary to the reference surface **5′** of the cartridge **1′** of FIG. **1B** with first channel **34′** aligned with access port **3′**.

Although not necessary for the invention, the plate may be configured with a second channel and plug for use in refilling a second ink cartridge. More particularly, the plate **30′** as shown in FIG. **2B** includes a second region **35′** which includes a second channel **36′** extending therethrough along axis **36***a′* with compliant sidewalls **36***b′*, similar to the region **33′** of plate **30′**. The bottom surface **32′** of plate **30′** includes a second mechanical alignment key **38″** and is contoured to be complementary to the reference surface **5′** of another cartridge **1′** of FIG. **1B** with second channel **36′** aligned with access port **3′**. When T_1 is equal to T_2, the plate **30** becomes essentially bilaterally symmetric. The first region **33′** and second region **35′** of the plate **30′**, being of equal thickness, may be used interchangeably in positioning a spherical plug in access ports of successively refilled cartridges (following orientation of the plate **30′** with the respective cartridges) using the plate **30′**.

The length **L1** of the elongated member of the plunger is greater than the thickness T_2 of the second region of the plate minus half the diameter D of the spherical plug, yet less than the sum of thickness T_2 and distance d by which the access port extends into the cartridge, minus half the diameter D of the spherical plug. This relationship between the length of the elongated member of the plunger, the plate thickness in the region **33′** and the diameter of the spherical plug ensures that when the plate is positioned onto the cartridge in its so-called first orientation, the elongated member of the plunger will extend through the second channel in the plate only far enough into the access port in the cartridge to position a spherical plug in the access port, thereby sealing it. The shoulder of the plunger will not permit the elongated member to extend far enough into the access port to push the spherical plug beyond the distance d by which the access port extends into the cartridge.

FIGS. **4A–4F** and **5A–5C** illustrate schematically a method of opening, refilling and sealing a cartridge, shown in FIG. **4A**, according to the invention. As shown in FIG. **4B**, use of the plate to open the cartridge is optional, since it is merely necessary to extend the elongated member of the plunger into the port sufficiently far to dislodge the sealing plug therein, and this operation may be performed without the plate. However, some ink cartridges, such as the type illustrated in FIG. **1A**, contain delicate electrodes **7** on the reference surface **5** which could be damaged if not protected from contact by the plate. In circumstances where protection of the electrodes on the reference surface of the cartridge is desired, the plate may be used as follows to open the sealed access port in the cartridge. As shown in FIG. **4C**, the bottom surface **32** of plate **30** is matched to the reference surface **5** and alignment keys **6** of depleted ink cartridge **1** having access port **3** sealed with plug **8** such that the channel axis **36***a* in the second region **35** is collinear with the port axis **3***a*. As shown in FIG. **4D**, elongated member **23** of plunger **20** is extended through the second channel **36** in the plate and into the access port **3** until the shoulder **24** of the plunger **20** meets the top surface **31** of the plate **30**. Extension of the elongated member **23** to this depth will dislodge the plug **8**, thereby sealing access port **3** in the cartridge **1** and releasing the plug **8** into the interior reservoir **2** of the cartridge **1**. The plunger **20** may then be withdrawn from the plate **30** and the plate removed from the cartridge **1**.

Release of the plug into the interior reservoir of the cartridge does not hinder the flow of ink through the ink jets nor displace significant volume within the ink reservoir, as shown in FIGS. **4E** and **4F**.

The ink cartridge may then be refilled with a dispensable liquid substance, such as ink, through the open access port in any manner known in the art for refilling cartridges, as shown in FIG. **4E**.

The filled cartridge may be resealed using the plate **30** which nominally contains plug **40** positioned within the first channel **34**, as shown in FIGS. **5A** and **5B**. In FIG. **5A**, the bottom surface **32** of the plate **30** is matched to the reference surface **5** and alignment keys **6** of the cartridge **1** in a first orientation such that the first channel axis **34***a* is collinear with the port axis **3***a*. In FIG. **5B** the elongated member **23** of the plunger **20** is then inserted from the top surface **31** of the plate **30** through the first channel **34** into the port **3** in the cartridge **1** until the shoulder **24** of the plunger **20** meets the top surface **31** of the plate **30**, as shown in FIG. **5C**. Extension of the elongated member **23** into the access port **3** to this depth ensures that the rigid spherical plug **40** is pushed into the access port **3**, thereby sealing it, but not into the interior reservoir **2** of the cartridge **1**. The plunger **20** may then be withdrawn from the plate **30** and the plate removed from the cartridge **1**. After removing the plate **30** a patch P (shown on FIG. **5C**) may be adhered to the reference surface **5** about the access port **3**.

By using the present invention, a depleted cartridge may be opened, refilled and resealed instead of discarded after a single use, thereby extending its useful life.

The kit of FIG. **2B** may be similarly used to open, fill and reseal the cartridge **1′** of FIG. **1B**. Initially, the plunger **20′** may be used to push the plug **8** into the reservoir **2′**. Then, preferably, the lateral walls **9′** of the cartridge **1′** are nominally squeezed together to pressurize an interior ink storage bladder, for example, and the cartridge **1′** is refilled with ink. The bottom surface **32′** of plate **30′** is then matched to the reference surface **5′** of the cartridge **1′**, as shown in FIG. **9**, with alignment keys **6′** and **38′** aligned, and port **3′** and channel **34′** aligned. Then the plunger **20′** drives the plug **40′** in plate **30′** into the sealing position in the cartridge wall, completing the method. The plate **30′** may then be used in a similar manner (but with channel **36′**) to refill a second cartridge.

Another kit **10″** embodying the invention is shown in FIG. **10**, for use with the cartridge of FIG. **1A**. In FIG. **10**, elements which correspond to elements in FIG. **2A** are identified with identical but double primed reference designations. The kit **10″** of FIG. **10** includes a plunger having a shank **22″** with a first elongated member **23***a″* extending a distance **L1** along a first plunger axis **20***a″* from shoulder **24***a″* and a second elongated member **23***b″* extending a distance **L2** along a second plunger axis **20***b″* from shoulder **24***b″*. The elongated members **23***a″* and **23***b″* have a maximum cross-section dimension less than or equal to D, and the shoulders **24***a″* and **24***b″* have cross-sections with a maximum dimension greater than D. As illustrated, axis **20***a″* is

angularly offset with respect to axis 20*b*'', but those axes may be parallel or co-linear in other forms.

In the kit **10**'', the plate **30**' has a uniform thickness for both channels **34**' and **36**' (i.e. T1=T2) and the lengths L1 and L2 are selected to clear the access port and seat a plug in that port respectively, when the plate **30**' is successively placed in its second and first orientations, respectively. More particularly, $T1-D/2<L1<T1+d-D/2$ and $L2>T2+d-D/2$.

In other embodiments, where the channels **34**'' and **36**'' are in differing thickness regions of plate **30**'. The lengths L1 and L2 are selected accordingly to effect clearing the access port and seating a plug in that port respectively.

Other alterations to the above-described embodiments will be readily apparent to those ordinarily skilled in the art and are intended to be embraced within the spirit and scope of the invention. That is, the above description is intended as illustrative rather than limiting. The invention is to be defined, therefore, not by the preceding description but by the claims that follow.

We claim:

1. A kit for opening and sealing a cartridge having an interior ink reservoir coupled to a sealable access port defined by a nominally cylindrical wall extending from a reference surface of said cartridge, said access port having a nominally circular cross-section with diameter D extending a distance d along a port axis substantially perpendicular to said reference surface, comprising:

A. a plunger having at least one shank, said one shank extending along a first plunger axis to a shoulder having a transverse cross-section with a maximum dimension greater than D, and having an elongated member extending a length L1 from said shoulder along said first plunger axis, said elongated member having a transverse cross-section with a maximum dimension less than or equal to D;

B. a plate having a top surface and a bottom surface and a thickness T_1 in a first region and having a first channel extending through said first region along a first channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a first orientation, said first channel axis being oriented with respect to said bottom surface in said first orientation in the same manner that said port axis is oriented with respect to said reference surface; and

C. at least one plug extending along a plug axis, said at least one plug having a circular transverse cross-section at its widest point with a diameter greater than or equal to D, whereby said at least one plug is adapted for friction fit within said first channel of said plate,

wherein $T_1-F<L1<T_1+d-F$ and wherein F is the distance from one end of said plug along its axis to its nearest circular transverse cross-section having diameter D.

2. A kit according to claim **1** wherein said plug is relatively rigid compared to said cylindrical wall said part.

3. A kit according to claim **1** wherein said plug is relatively compliant compared to said cylindrical wall of said part.

4. A kit according to claim **1** wherein said plug and said cylindrical wall of said part are relatively rigid.

5. A kit according to claim **1** wherein said plug and said cylindrical wall of said part are relatively compliant.

6. A kit according to claim **1** wherein one of said plugs is nominally positioned within said first channel with a friction fit.

7. A kit according to claim **6** wherein said plug is one from the group consisting of spheroid, ellipsoid, extended ellipsoid, conic frustum, and cylinder.

8. A kit according to claim **7** wherein said plug is a spheroid and F=D/2.

9. A kit according to claim **1** wherein said cross-section of said first channel has a maximum diameter D at said bottom surface of said plate and has a lesser diameter otherwise.

10. A kit according to claim **1**, wherein said bottom surface of said plate is complimentary to said reference surface in said first orientation.

11. A kit according to claim **1** wherein said plate further includes a second region having thickness T_2, where $T_2<T_1$, and having a second channel extending through said second region along a second channel axis perpendicular to the plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a second orientation, said second channel axis being oriented with respect to said bottom surface in said second orientation in the same manner that said port axis is oriented with respect to said reference surface and

wherein $L1>T_2+d-F$.

12. A kit according to claims **11** wherein said plug is relatively rigid compared to said cylindrical wall of said part.

13. A kit according to claim **11** wherein said plug is relatively compliant compared to said cylindrical wall of said part.

14. A kit according to claim **11** wherein said plug and said cylindrical wall of said part are relatively rigid.

15. A kit according to claim **11** wherein said plug and said cylindrical wall of said part are relatively compliant.

16. A kit according to claim **15** wherein said plugs is one from the group consisting of sphereoid, ellipsoid, extended ellipsoid, conic frustum, and cylinder.

17. A kit according to claim **16** wherein said plug is a spheriod and F=D/2.

18. A kit according to claim **11** wherein one of said plugs is nominally positioned within said first channel with a friction fit.

19. A kit according to claim **11** wherein said cross-sections of said first and second channels have a maximum diameter D at said bottom surface of said plate and have a lesser diameter otherwise.

20. A kit according to claim **11** wherein said bottom surface of said plate is complimentary to said reference surface in said first orientation and in said second orientation.

21. A kit according to claim **1** wherein said plate further includes n additional regions, where n>O each of said additional regions having thickness Ti; and having an associated additional channel extending through said second region along a second channel axis substantially perpendicular to the principal plane of said plate, and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface permitting alignment with said refer-

ence surface of said cartridge in a second orientation, said second channel axis being oriented with respect to said bottom surface in said second orientation in the same manner that said port axis is oriented with respect to said reference surface wherein $Ti-F<L-1<Ti+d-F$, and further includes one of said plugs.

22. A kit according to claim **21** wherein said plug is relatively rigid compared to said cylindrical wall of said part.

23. A kit according to claim **21** wherein said plug is relatively compliant compared to said cylindrical wall of said part.

24. A kit according to claim **21** wherein said plug and said cylindrical wall of said part are relatively rigid.

25. A kit according to claim **21** wherein said plug and said cylindical wall of said part are relatively compliant.

26. A kit according to claim **21** wherein one of said plugs is nominally positioned within said first channel with a friction fit and one of said plugs is nominally positioned within said one or more of said additional channels with a friction fit.

27. A kit acording to claim **26** wherein said plugs are ones from the group consisting of spheroid, ellipsoid, extended ellipsoid, conic frustum and cylinder.

28. A kit according to claim **27** wherein said plugs are spheroids and $F=D/2$.

29. A kit according to claim **21** wherein said cross-sections of said first and second channels have a maximum diameter D at said bottom surface of said plate and have a lesser diameter otherwise.

30. A kit according to claim **21**

wherein said bottom surface of said plate is complimentary to said reference surface in said first orientation and in said second orientation.

31. A kit according to claim **21** wherein $Ti=T_1$.

32. A kit according to claim **1** wherein said plunger includes a second shank, said second shank extending along a second plunger axis to a shoulder having a transverse cross-section with a maximum dimension greater than D, and having an elongated member extending a length **L2** from said shoulder along said second plunger axis, said elongated member having a transverse cross-section with a maximum dimension less than D, and

wherein said plate further includes a second region having thickness T_2, where $T_2 \leqq T_1$ and having a second channel extending through said second region along a second channel axis perpendicular to the plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a second orientation, said second channel axis being oriented with respect to said bottom surface in said second orientation in the same manner that said port axis is oriented with respect to said reference surface and wherein $L2>T_2+d-F$

33. A kit according to claim **32** wherein **T1=T2**.

34. A kit according to claim **32** wherein said first plug axis is angularly offset with respect to said second plug axis.

35. A kit according to claim **34** wherein said first axis and second plug axis intersect.

36. A kit according to claim **32** wherein one of said plugs is nominally positioned within said first channel with a friction fit.

37. A kit for opening and sealing a cartridge having an interior ink reservoir coupled to a sealable access port defined by a nominally cylindrical wall extending from a reference surface of said cartridge, said access port having a nominally circular cross-section with diameter D extending a distance d along a port axis substantially perpendicular to said reference surface comprising:

A. a plunger having at least one shank, said one shank extending along a first plunger axis to a shoulder having a transverse cross-section with a maximum dimension greater than D, and having an elongated member extending a length **L1** from said shoulder along said first plunger axis, said elongated member having a transverse cross-section with a maximum dimension less than or equal to D;

B. a plate having a top surface and a bottom surface and a thickness T_1 in a first region and having a first channel extending through said first region along a first channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a first orientation, said first channel axis being oriented with respect to said bottom surface in said first orientation in the same manner that said port axis is oriented with respect to said reference surface; and

C. at least one plug extending along a plug axis, said at least one plug having a circular cross-section at its widest point with a diameter greater than or equal to D, whereby said at least one plug is adapted for friction fit within said first channel of said plate,

wherein **L1** and **T1** are selected so that when said plate is positioned adjacent to said reference surface with said port axes and said first channel axes being aligned, and with said elongated member and said plug driven through said first channel and into said access port with said shoulder adjacent to said plate, said plug is interferingly fit in said access port.

38. A kit for opening and sealing a cartridge having an interior ink reservoir coupled to a sealable access port defined by a nominally cylindrical wall extending from a reference surface of said cartridge, said access port having a nominally circular cross-section with diameter D extending a distance d along a port axis substantially perpendicular to said reference surface, comprising:

A. a plunger having a shank extending between a first shoulder having a cross-section with a maximum dimension greater than D and a second shoulder having a transverse cross-section with a maximum dimension greater than D, and having a first elongated member extending a length **L1** from said first shoulder along a first plunger axis and having a second elongated member extending a length **L2** along a second plunger axis, said first and second elongated members each having a transverse cross-section with a maximum dimension less than or equal to D;

B. a plate having a top surface and a bottom surface and a thinkness **T1** in a first region and having a first channel extending through said first region along a first channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section having a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alingment with

said reference storage of said cartridge in a first orientation, said first channel axis being oriented with respect to said bottom surface in said first orientation in the same manner that said port axis is oriented with respect to said reference surface, and wherein said plate further includes a second region having thickness T2 and having a second channel extending through said second region along a second channel axis substantially perpendicular to the plane of said plate and having a transverse cross-section having a minimum dimension equal to D at said bottom surface, said botom surface of said plate permitting alignment with said reference surface of said cartridge in a second orientation, said second channel axis being oriented with respect to said bottom surface in said second orientation in the same manner that said port axis is oriented with respect to said reference surface; and

C. at least one plug extending along a plug axis, said plug having at its widest point a circular transverse cross-section with a diameter greater than or equal to D,

wherein $T1-F<L1<T1+d-F$ and $L2>T2+d-F$, and wherein F is the distance from one end of said plug along its axis to its nearest transverse circular cross-section having diameter D.

39. A kit according to claim **38** wherein $T1=T2$.

40. A method for opening, refilling and sealing a cartridge having an interior ink reservoir coupled to a sealable access port defined by a nominally cylindrical wall extending from a reference surface of said cartridge, said access port having a nominally circular cross-section with diameter D extending a distance d along a port axis substantially perpendicular to said reference surface, comprising the steps of:

A. providing a plunger having a shank, said shank extending along a plunger axis to a shoulder having a transverse cross-section with a maximum dimension greater than D, and having an elongated member extending a length L1 from said shoulder along said plunger axis, said elongated member having a transverse cross-section with a maximum dimension less than or equal to D;

B. providing a plate having a top surface and a bottom surface and a thickness T_1 in a first region and having and a first channel extending through said first region along a first channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a first orientation, said first channel axis being oriented with respect to said bottom surface in said first orientation in the same manner that said port axis is oriented with respect to said reference surface, and including a plug extending along a plug axis and having a circular transverse cross-section at its widest point having diameter D, said plug being nominally positioned within said first channel, wherein $T_1-F<L1<T_1+d-F$; and wherein F is the distance from one end of said plug along its axis to its nearest circular transverse cross-section having diameter D;

C. opening said sealed access port;

D. refilling said cartridge with a dispensable liquid substance through said access port;

E. aligning said bottom surface of said plate with said reference surface of said cartridge, thereby aligning said first channel with said access port in said cartridge; and

F. sealing said access port in said cartridge by inserting said elongated member into said first channel of said plate from said top surface until said shoulder meets said top surface, thereby pushing said plug into said access port, and then withdrawing said plunger and removing said plate from said cartridge.

41. The method of claim **40** wherein said step C comprises inserting said elongated member of said plunger through said access port to penetrate the seal therein and then withdrawing said plunger from said access port.

42. The method of claim **40** including the further step of:

G. adhering a patch to said reference surface about said access port.

43. A method for opening, refilling and sealing a cartridge having an interior ink reservoir coupled to a sealable access port defined by a nominally cylindrical wall extending from a reference surface of said cartridge, said access port having a nominally circular cross-section with diameter D extending a distance d along a port axis substantially perpendicular to reference surface, comprising the steps of:

A. providing a plunger having a shank, said shank extending along a plunger axis to a shoulder having a transverse cross-section with a maximum dimension greater than D, and having an elongated member extending a length L1 from said shoulder along said plunger axis, said elongated member having a transverse cross-section with a maximum dimension less than or equal to D;

B. providing a plate having a top surface and a bottom surface and having a thickness T_1 in a first region and having a first channel extending through said first region along a first channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a first orientation, said first channel axis being oriented with respect to said bottom surface in said first orientation in the same manner that said port axis is oriented with respect to said reference surface and including plug having a cross-section of diameter D nominally positioned within said first channel, and further including a second region having thickness T_2, where $T_2<T_1$, and having a second channel extending through said second region along a second channel axis substantially perpendicular to the principal plane of said plate and having a transverse cross-section with a minimum dimension in at least one direction equal to D, said bottom surface of said plate permitting alignment with said reference surface of said cartridge in a second orientation, said second channel axis being oriented with respect to said bottom surface in said second orientation in the same manner that said port axis is oriented with respect to said reference surface, and including a plug having a cross-section of diameter D nominally positioned within said second channel,

wherein $L1>T_2+d-F$ and $T_1-F<L1<T_1+d-F$; and wherein F is the distance from one end of said plug at along its axis to its nearest transverse cross-section having diameter D,

C. aligning said bottom surface of said plate with said reference surface of said cartridge in said second orientation, thereby aligning said second channel with said access port in said cartridge;

D. opening said sealed access port by inserting said elongated member into said second channel of said plate from said top surface until said shoulder meets said top surface, thereby pushing said elongated member of said plunger through said second channel into said port to penetrate the seal therein, and then withdrawing said plunger from said access port and removing said plate from said cartridge;

E. refilling said cartridge with a dispensable liquid substance through said access port;

F. aligning said bottom surface of said plate with said reference surface of said cartridge in said first orientation, thereby aligning said first channel with said access port in said cartridge; and

G. sealing said access port in said cartridge by inserting said elongated member into said first channel of said plate from said top surface until said shoulder meets said top surface, thereby pushing said plug into said access port, and then withdrawing said plunger and removing said plate from said cartridge.

44. The method of claim **43** including the further step of:

H. adhering a patch to said reference surface about said access port.

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